



Test and Evaluation/Science and Technology Program

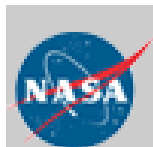
Embedded Instrumentation “Technology Enabled T&E Process Transformation”

Presented by:

George Shoemaker, Ph.D.

EI Executing Agent

**Naval Undersea Warfare Center,
Division Newport**





T&E/S&T Program

- Leverages successful applied research and ongoing advanced technology development by transitioning S&T efforts from labs, academia, and industry to T&E capability developers and users
- Funds test technologies that keep pace with evolving weapons technology
- Ensures that we have the technology to adequately test future advanced systems



T&E/S&T Program Background

- ┌ **Program started in FY 2002**
 - Joint DDR&E/DOT&E initiative
 - Transitioned to TRMC in February 2005
- ┌ ***Mission***
 - Develop new technologies required to test and evaluate our transforming military capabilities
 - ┌ Includes any system that makes our warfighters more survivable and effective in combat
 - Lethal and non-lethal weapons
 - Intelligence surveillance and reconnaissance
 - Information systems
- ┌ ***Goal***
 - Transition emerging technologies into test capabilities in time to verify warfighting performance



T&E/S&T Program Mission

- Develop the technologies required to test and evaluate our transforming military capabilities
 - Includes any system that makes our warfighters more survivable and effective in combat:
 - Lethal and non-lethal weapons
 - Intelligence, surveillance and reconnaissance systems
 - Information systems
- Provide the required test and evaluation technologies in time to verify performance before production or deployment into harm's way



T&E/S&T Program

Roles and Responsibilities

■ Focus Area Executing Agents

- Primary point of contact for T&E/S&T Program Office within focus area
- Maintain awareness of DoD T&E needs within focus area and technology developments related to focus area
- Actively seek out high payoff T&E/S&T projects that address critical DoD T&E needs
- Issue Requests for Information (RFIs) and Broad Agency Announcements (BAAs) through contractual channels
- Responsible for technical and financial execution of projects approved by T&E/S&T Program Manager
- Chair for focus area working group (WG) and responsible for maintaining Tri-Service WG T&E and S&T representation
 - Coordinate replacements with T&E/S&T Program Manager
- Responsible for maintaining current project and focus area information in TESTWeb and T&E/S&T ACC Special Interest Area



T&E/S&T Program

Roles and Responsibilities

- Focus Area Working Group Members
 - Provide coordination of T&E/S&T projects with Service related efforts
 - Identify and prioritize T&E needs
 - Support the EA on source selection efforts
 - Review ongoing focus area projects
 - Identify transition opportunities for projects

- Project Principal Investigators
 - Single point of contact for executing projects approved by T&E/S&T Program Manager
 - Responsible for conducting research efforts
 - Responsible for maintaining accurate financial information in TESTWeb
 - Provide technical progress reports to EA and T&E/S&T Program Manager
 - Identify and actively pursue transition opportunities for T&E/S&T projects



T&E/S&T Program Organization

T&E/S&T Program Office

G. Rumford (Program Manager)
R. Barrett (Principal Engineer)
Dr. M. Brown (Principal Scientist)
D. Gaddy (Financial)

Hypersonic Test

J. Matty (EA)
Dr. B. Phillips (Deputy)

Subj Matter Expert
Various

Financial

Tri-Service
Working Group

Spectrum Efficient Technology

S. Ortigoza (EA)
R. Streich (Deputy)

Subj Matter Expert
Dr. D. Schaefer

Financial

Tri-Service
Working Group

Multi-Spectral Test

F. Carlen (EA)
L. Huynh (Deputy)

Subj Matter Expert
Dr. S. Gontarek

Financial

Tri-Service
Working Group

Directed Energy Test

M. Vuong (EA)
A. Kapadia (Deputy)

Subj Matter Expert
Various

Financial

Tri-Service
Working Group



Embedded Instrumentation

Dr. G. Shoemaker (EA)
J. Hooper (Deputy)

Subj Matter Expert
Dr. S. Zakanycz

Financial

Tri-Service
Working Group

Netcentric Systems Test

R. Heilman (EA)
G. Torres (Deputy)

Subj Matter Expert
Various

Financial

Tri-Service
Working Group



A History of Warfare

The fundamental military strategy has always been the massing of force with a focus on “attrition warfare”

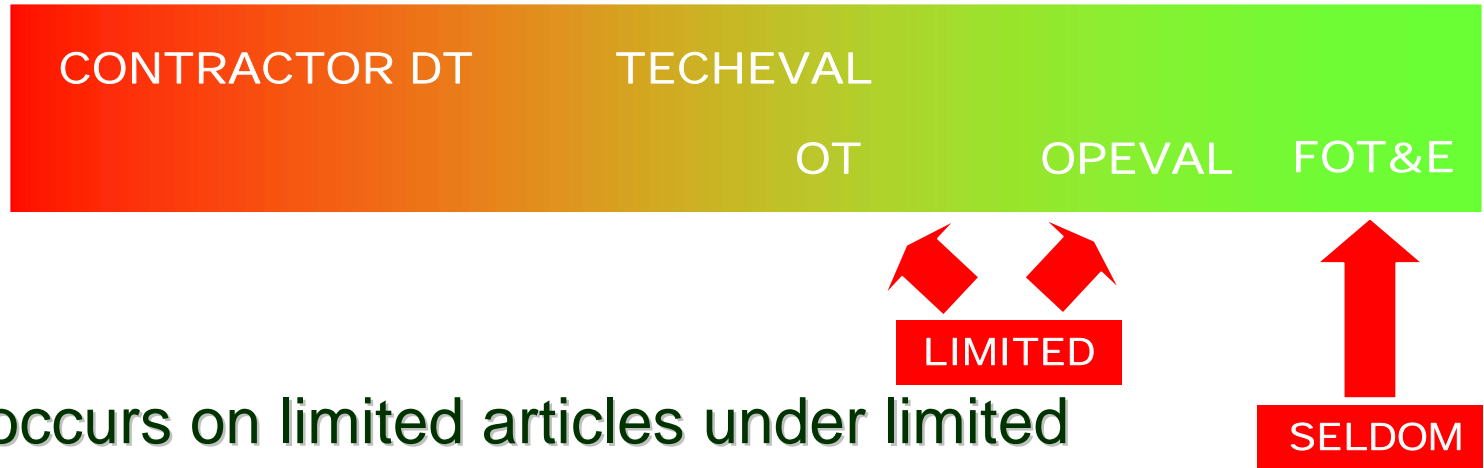
Unmanned combat vehicles, precision guided munitions, and full situational awareness signify the advent of “effects-based warfare”



We have only just begun the “Technology Enabled Warfighting Transformation”



Current T&E Process



- OT occurs on limited articles under limited scenarios a limited number of times
- Many operational characteristics can only be ascertained over extended periods time and widely varying tactical scenarios
- Time, cost, and test resource availability are significant issues that impact effective OT

T&E is a cornerstone of acquisition

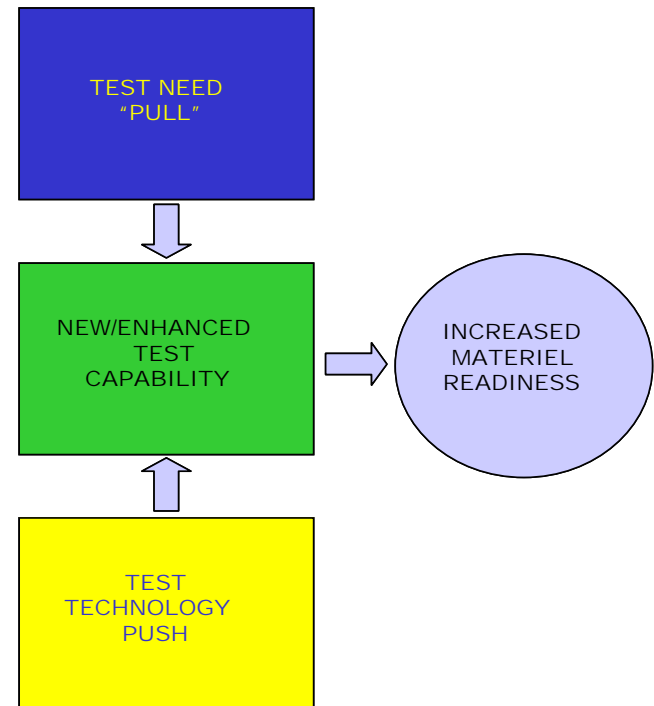


Test Capability Needs

- Hard test requirements & needs are difficult to establish because of acquisition program financial accountability
- While warfighting systems can be driven by “technology push”

*Advances in test technology
seldom drive new test
capability*

- Test planning usually revolves around available test resources and capabilities





Test Capability Solutions



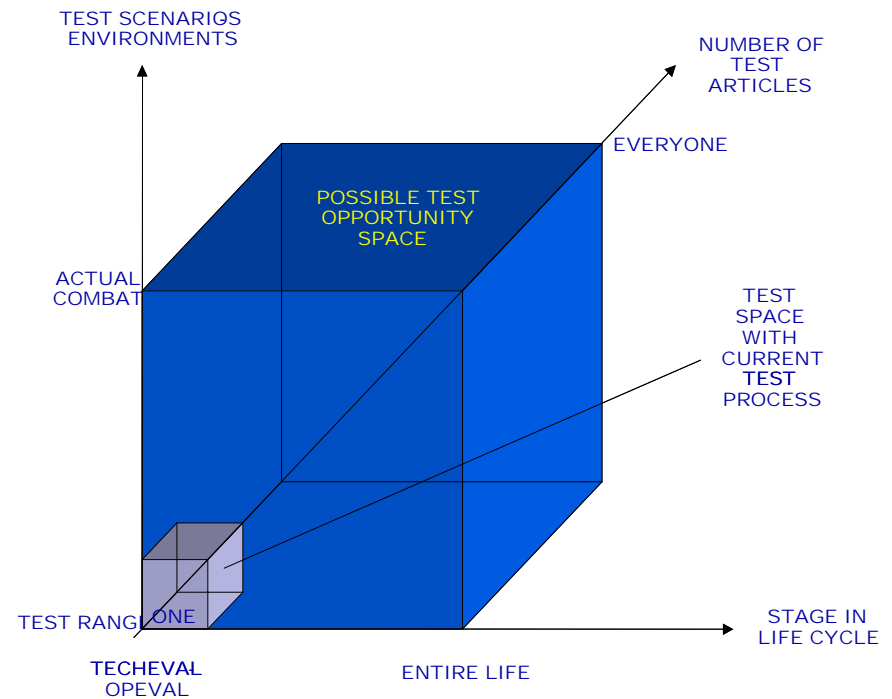
- There is always a need to balance risk with project executability
- Executability drives test capability solutions towards lower risk, more mature technologies

Without an infusion of new technology, test capabilities may not keep pace with the systems being tested



T&E Vision for the Future of Embedded Instrumentation

- Test data is now collected for only a limited set of circumstances - *Once*
- EI enables an expansion of the test opportunity space
 - To include all systems produced
 - For the full life of each system
 - From the DT/OT events to every training exercise and combat mission
- EI has the potential to transform the T&E Process from single discrete events to a continuous measurement cycle for each warfighting system



“Technology Enabled T&E Process Transformation”

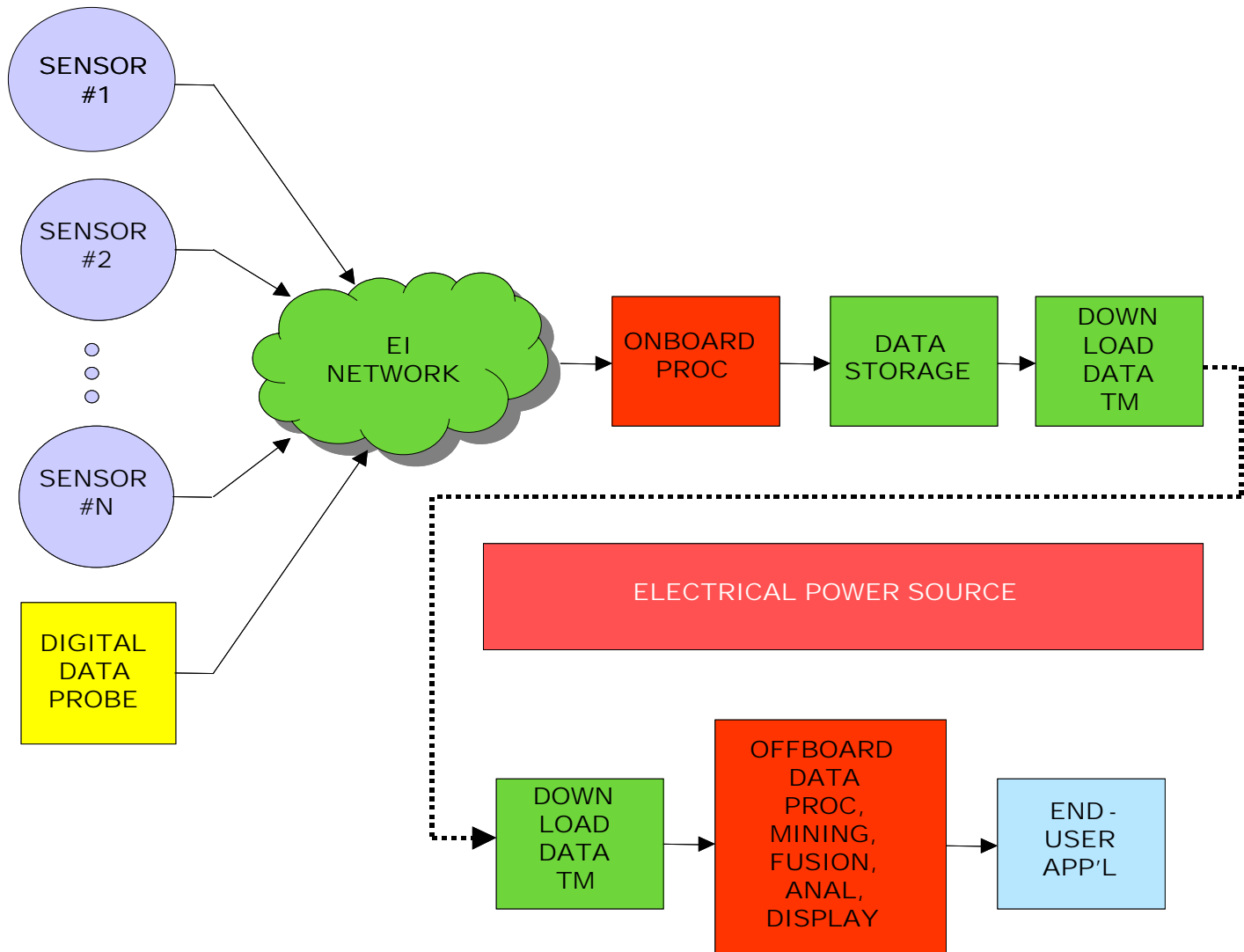


Embedded Instrumentation System

An Embedded Instrumentation System (EIS) is an integrated suite of specialized components that provides information about a host system to a person or process who evaluates the information to make technical and/or programmatic decisions about the present and/or future design of the host system. The systems of concern include the warfighting system itself as well as all necessary supporting systems such as but not limited to test and evaluation, training and logistics support systems and may be a standalone systems, a subsystem thereof, or a system of such systems. It is characterized as performing its functions as an integrated part of the host system installed therein as part of the original system design or added separately (appliqué) after the basic host system design. The EIS components may be self-powered and are of such size and weight as to not impact the design, fabrication, and/or performance of the host system (non-intrusive). Further, integration is such that its mis-performance or failure does not in any way affect the performance of the host system.



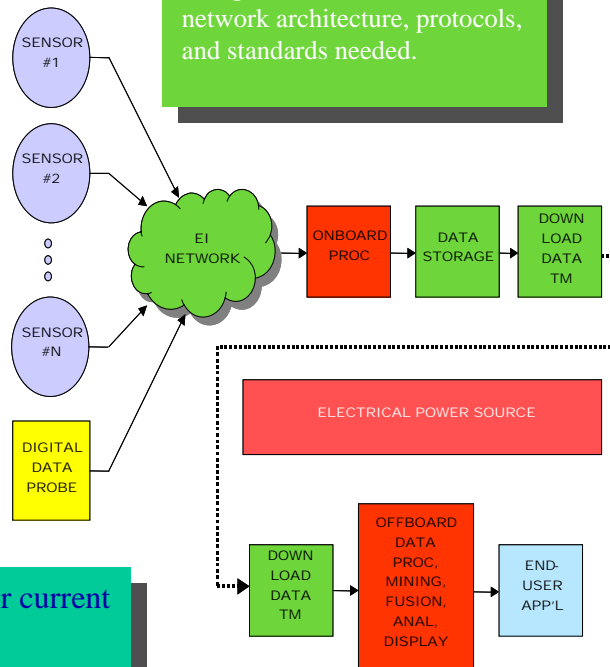
Embedded Instrumentation System



- **Data Collection:** The gathering of analogue and/or digital data pertaining to the characteristics and/or performance of the host system and its environment. It includes transducers intended to convert any form of energy into electrical energy bearing a known functional relationship to the source energy as well as specialized mounting/installation technologies. Included are software applications intended to mine data from the host system.

- **Electrical Power:** A voltage and/or current source intended to operate the EIS components and able to operate independently of the host system. Power may be provided as a primary or secondary electrical storage device and/or as a generator. A generator may convert any form of potential or kinetic energy available from the host system or the environment into electrical energy and/or provide for the sympathetic absorption and conversion of electrical power from the host system or any external energy field.

- **Data Transport** which moves data from the collection device to point in the EIS which may include a processor, storage, and/or telemetry system and includes the physical medium over which the data is transported as well as the network architecture, protocols, and standards needed.



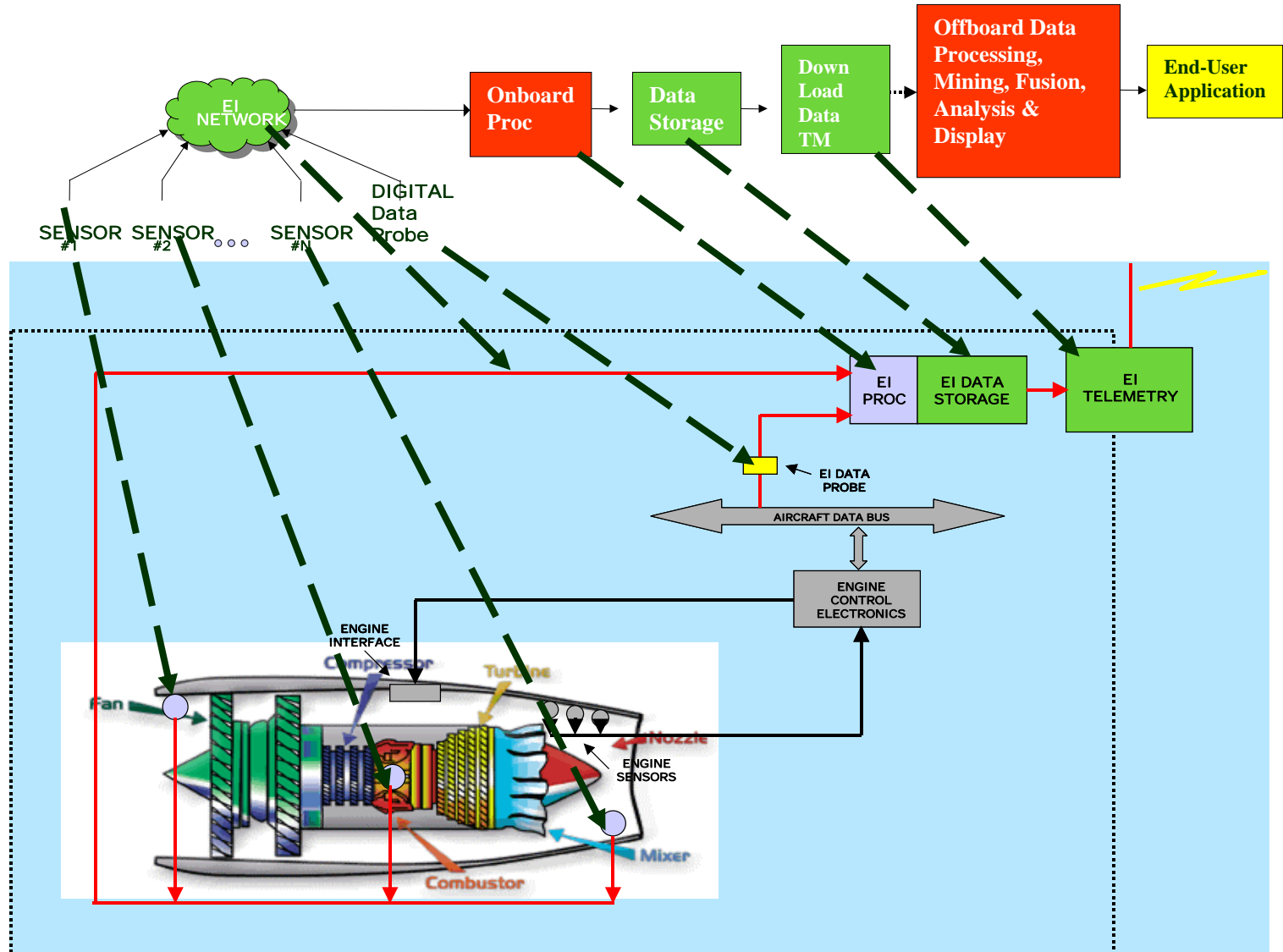
- **On-Board Data Storage:** Any technology located onboard the host system capable of storing analogue and/or digital data in raw or processed form for purposes of archiving, processing, and/or evaluation at a later time. It includes the storage medium as well as the read/write functionality of the technology.

- **Data Telemetry:** The function of transporting data and/or information off the host system in real-time or post-event to an end user as well as the offboard control of the EIS by the end user. TM is medium independent. The EI Focus includes the development of new technology for the establishment of a conventional TM capability and/or miniaturization and/or hardening of telemetry components as they reside on or in the host system but does not include the development of telemetry media or telemetry protocols and standards.

- **Data Processing:** The application of specialized algorithms implemented in hardware and/or software to prepare the data for transport, storage and/or telemetry as well as processing, analysis, evaluation, and display. It includes but is not limited to data reduction/compression, fusion, and encryption. Processing may take place on or in the host system or offboard the host system.



Example EIS Integration





Embedded Instrumentation Vision

- *Develop and demonstrate non-intrusive embedded instrumentation sensors, power sources, data storage technologies and architecture concepts that enhance T&E of warfighting systems, reduce the cost of data collection and improve interoperability and standardization on ranges. Specific objectives include:*
 - *Sensing and collecting critical test performance data*
 - *Enhancing data storage and transmission*
 - *Determining high accuracy and continuous time, space, position, and attitude information*
 - *Interfacing with command and control data links*
 - *Monitoring and reporting all communications and their responses*
 - *Reporting human operator performance*



ET Challenges and Approach

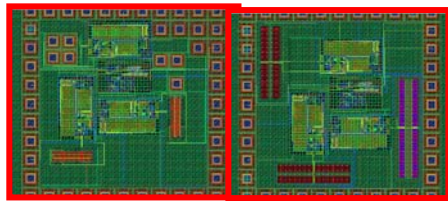
- **Challenge:** *Instrumentation requirements for future systems-under-test and hardware-in-the-loop testing are increasing exponentially. Early involvement of Test and Evaluation in the acquisition cycle is essential.*
- **Approach:** *Develop enabling technologies for miniaturized non-intrusive instrumentation suites that demonstrate increased survivability.*
 - *improved sensitivity sensors*
 - *new demonstrations in alternative and micro-power generation to power test instrumentation*
 - *increased embedded data processing capacity*
 - *both plug-and-play and open architectures to support multiple applications and users (development, test and evaluation, training, logistics and operational employment).*



ET Technology Overview

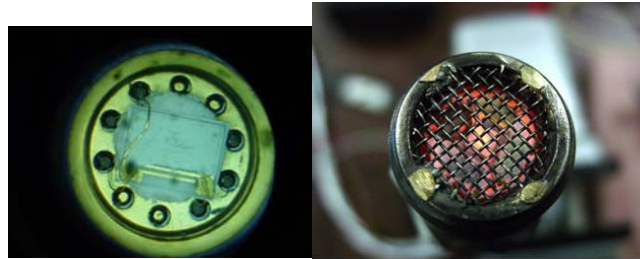
Micro-Sensors

AMFTI

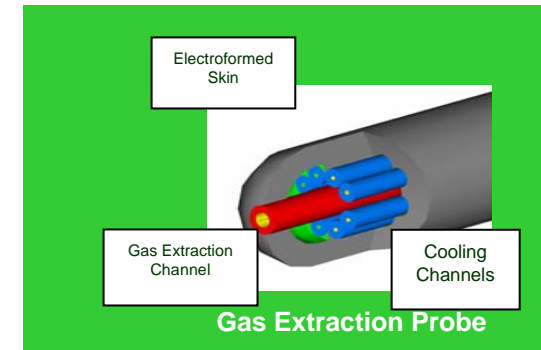


2-axis magnetometer 3-axis high-g accelerometer

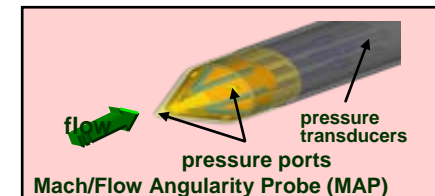
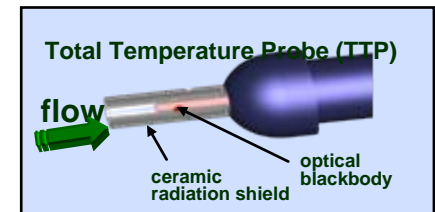
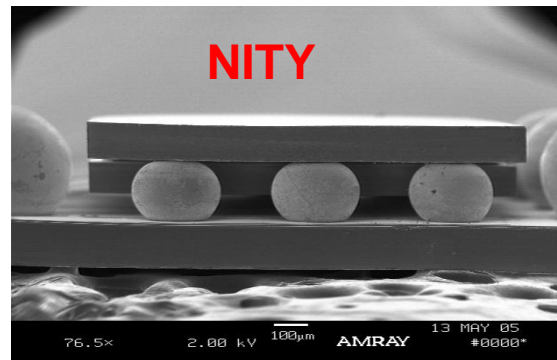
CO MEMS



GTE PROBE



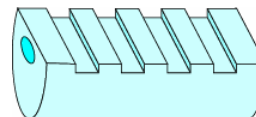
NITY



Pressure Sensor

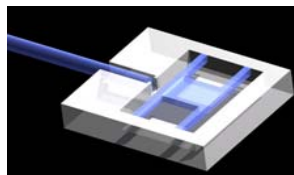
Temperature Sensor

D FIBER



FSIM

MEMS FO SENSORS

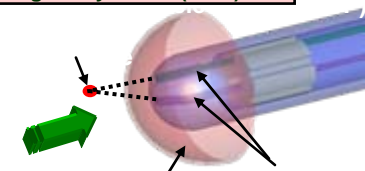


Shear Stress Sensor

HEDFS



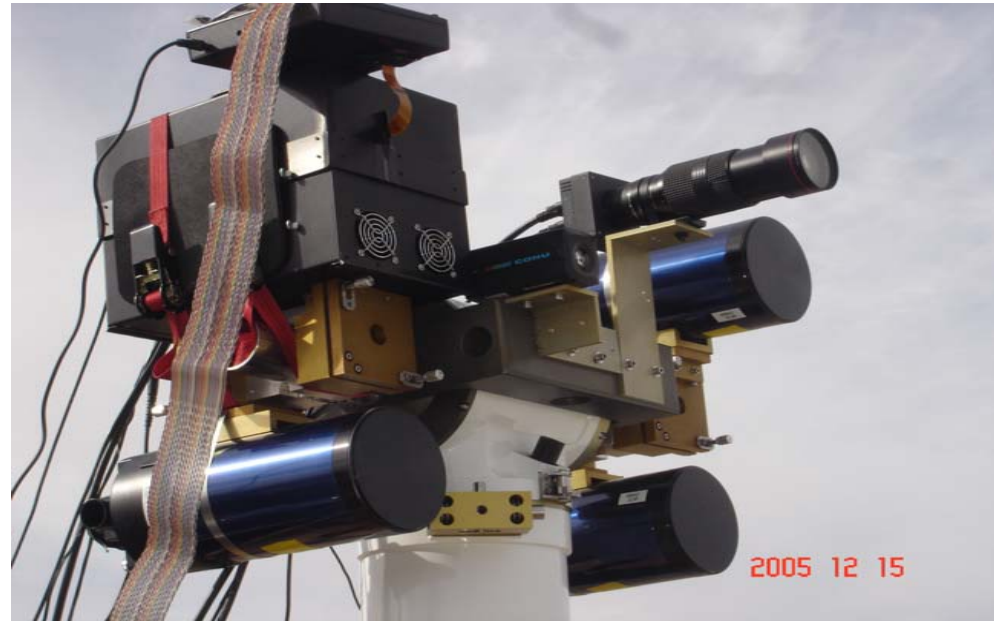
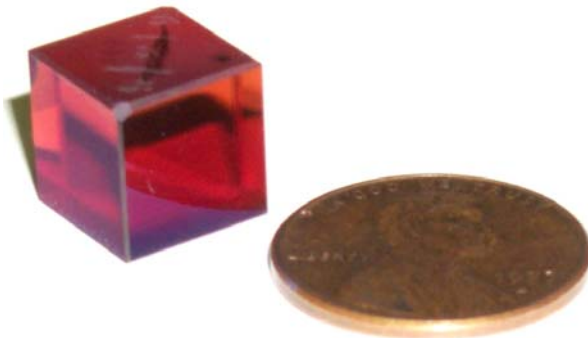
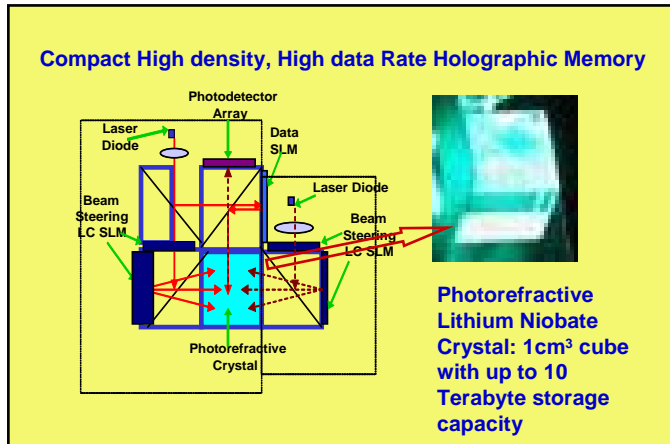
HSTD



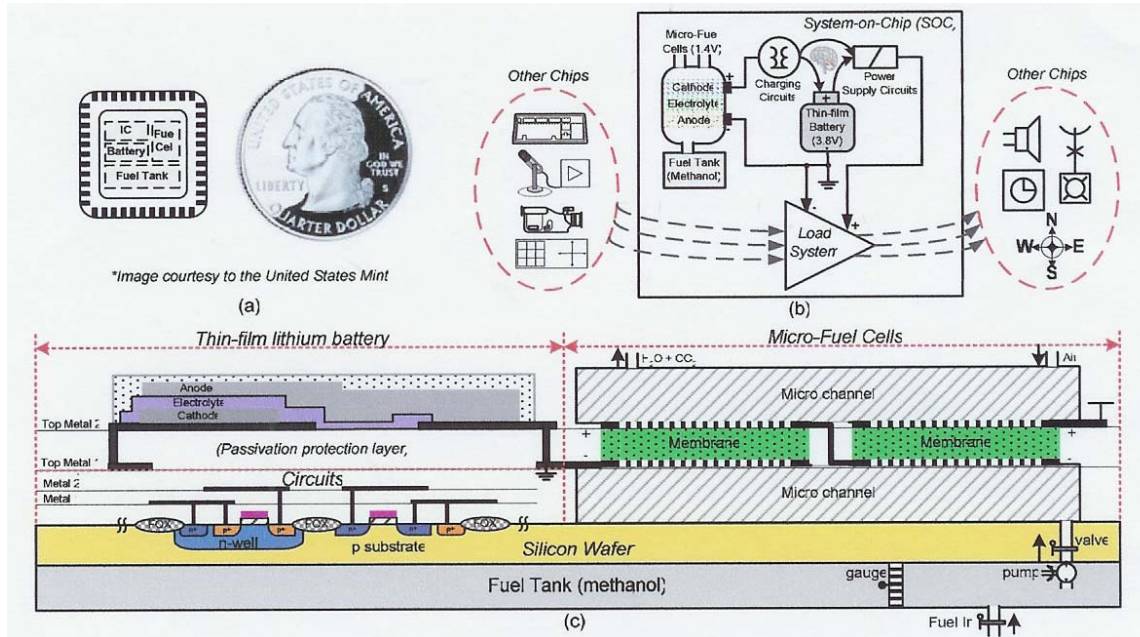
EI Technology Overview

Advanced Data Storage

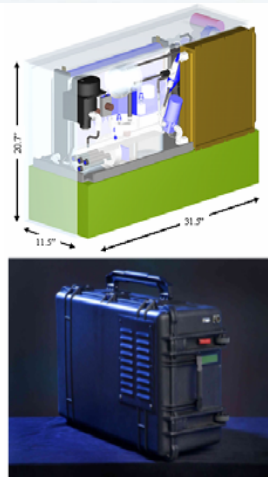
HOLO CUBE







**Self-Powered
Chip**



System Specifications	
Electrical:	
• Output Voltage:	20 to 30 V
• Power:	300 W
• Max Current:	15 A
Physical:	
• Dimensions:	31.5 in x 20.7 in x 11.5 in
• Mass:	55.6 kg (122.6 lb)
• Volume:	123 L (4.3 ft ³)
• Figures of Merit:	539.5 Wh/kg, 243 Wh/L
Fuel Cell System	
• System Mass:	17.7 kg (39 lb)
Fuel Tank	
• Fuel:	Methanol (Supplied from internal fuel tank)
• Capacity:	30000 Whr
• Tank Volume:	32 L (1.1 ft ³)
• Fuel Mass:	25.2 kg (55.5 lb)
Operational Environment:	
• Air Quality:	High dust concentration, 20 times zero visibility (~5 gm/m ³ of ACS Coarse 30 microns dust)
• System Startup:	Instantaneous when ambient temperature is greater than 5 °C (41 °F)
• Wet Storage:	5 to 70 °C (158 °F)
• Air Temperature:	-17 to 45 °C (113 °F)
• Altitude Sensitivity:	+/- 45° to vertical
• Shock and Vibration:	Survive a three-foot drop on concrete
• Unit must be protected during wash rack cycle.	

**Direct Methanol
Fuel Cell**



The “Stack” (approx 16 in long)



EI Technology Overview

Architecture

T&E Today



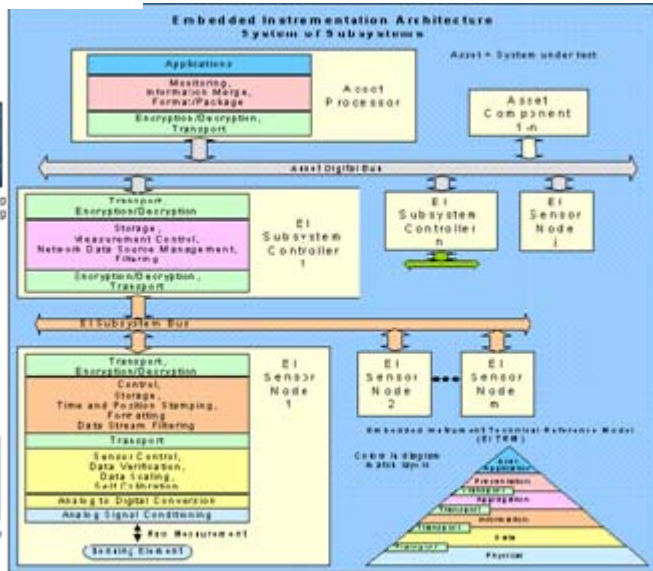
Current Data Recording and Signal Conditioning Equipment



Raceways, 12th Conduit, and Cable Trays



Peacekeeper Inertage Connector 174 Pins



T&E Future



Miniaturized Sensor and Components

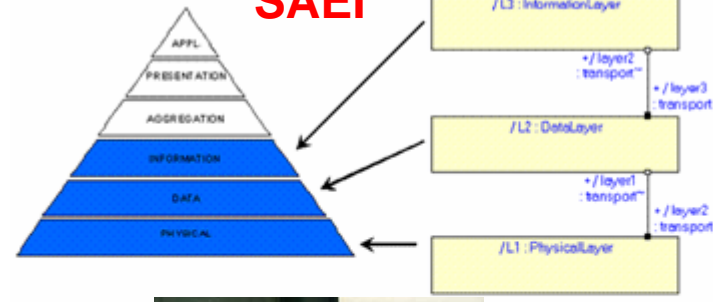


Simple Cable Four-Wire Solution



Network Bus Connector 6 Pins

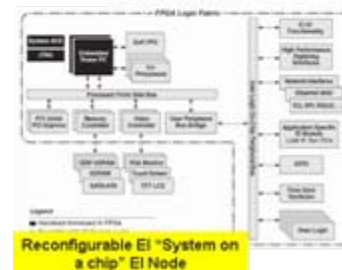
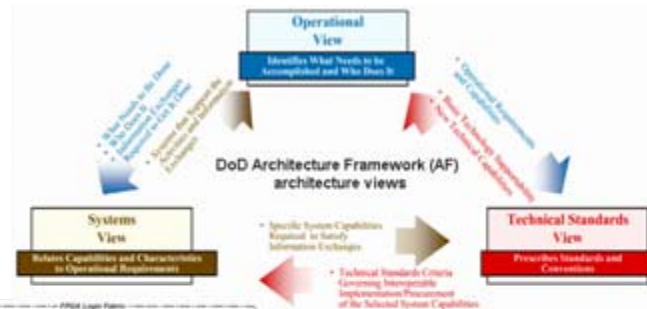
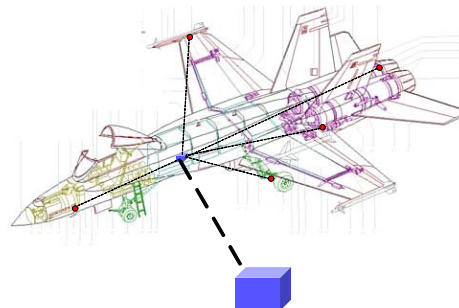
SAEI



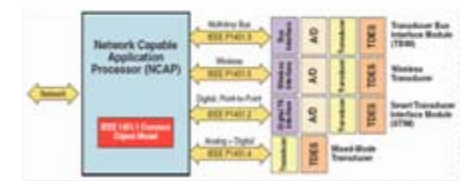
PC/104-based Embedded Demonstration Platform

DCTDB

OBWDC



Reconfigurable EI "System on a chip" EI Node

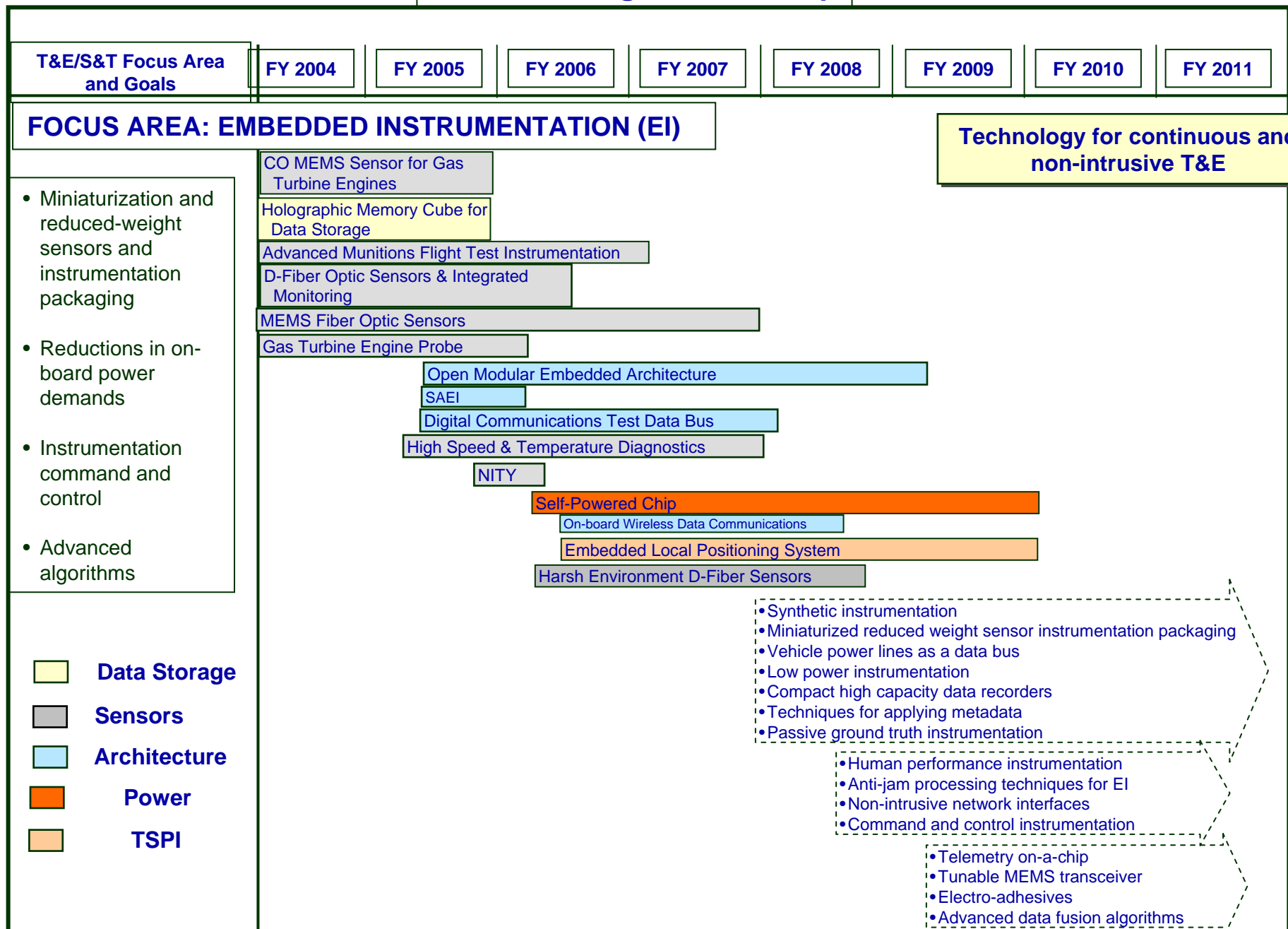


IEEE 1451 family of smart transducer interfaces

OMEA



T&E/S&T Program Roadmap



Technology for continuous and non-intrusive T&E



T&E/S&T Program

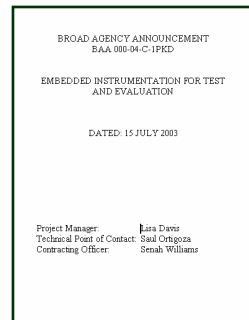
Project Selection



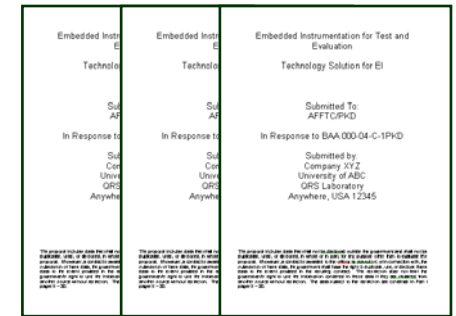
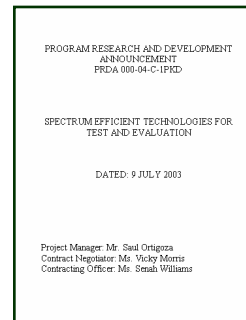
Tri-Service Focus Area Working Group

- Executing Agent
- T&E Community Reps
- S&T Community Reps
- Subject Matter Experts

Needs/Requirements



Solicitations



Proposals



Final
Selections

Executing
Agent

Recommendations

Source Selection Evaluation Team

- Working Group
- Subject Matter Experts
- Contracting Reps

Focus Area
Execution

Funding Decision



FY07 BAA Plans

- Two Step Process
 - 3-page abstract due on 20 July 2006
 - Specific focus areas of interest for FY 2007
 - Synthetic instrumentation
 - Miniaturization/reduced weight sensor and instrumentation packaging
 - Connectivity
 - Non-conventional power sources
 - Micro-power sources
 - Techniques for applying metadata
 - Self-describing smart sensors
 - TSPI on a chip
 - Micro-sensors
- Next Step
 - Government will invite proposals after abstract evaluations on 7 August 2006 (You may still submit a proposal even if you don't receive an invitation letter. It will be evaluated without prejudice).
 - 25-page technical/management proposal due September 07 2006
 - EIWG proposal evaluations mid September 2006
 - Recommendations to PMO in October 2006
 - Awards in November-December 2006

Broad Agency Announcement: EI BAA 1234

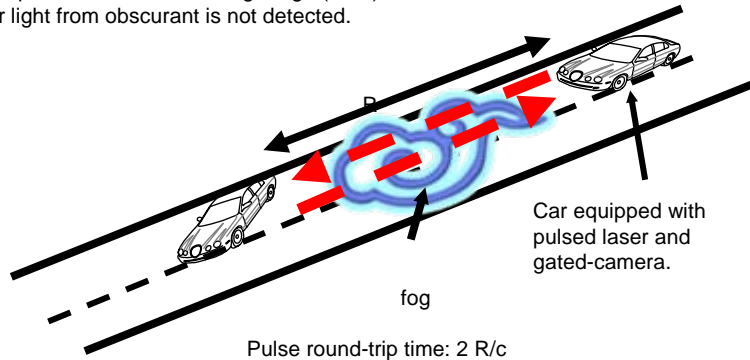
Principal EI Component Area: Sensors

Principal Investigator: Dr. Simon Simon

Proposal Title: Enhanced Infrared Sensor for Obscured Viewing Conditions

Enhanced IR Sensor Operating Principle

Emit ~ 20 ns laser pulse; gate camera at a time that corresponds to desired viewing range ($2R/c$). Scattered laser light from obscurant is not detected.



Operational Capability to Be Provided:

The Enhanced Infrared Sensor will be capable of providing illumination for a large area during fog or smoke conditions with infrared light

The sensor is connected to a high-density recorder.

System uses sophisticated camera design and gated laser sampling techniques.

The Enhanced IR Sensor has the following operational capabilities:

- Ability to penetrate fog and smoke conditions to produce a “gated view”
- Calculated MBTF of this technology is well beyond 20,000 hours
- Ability to form variety of beam patterns at different power levels
- Exceeds current state-of-the-art for eye safety margin by 10x
- Supports calculation of range to viewed objects

Proposed Technical Approach:

Task 1

- Engineering Design and Development
- Requirements definition
- HW/SW development
- Produce a brassboard test unit

•Task 2

- System Integration and Laboratory testing
- Interim Report

Task 3

- Field Testing enhanced infrared sensor

Task 4

- Sensor packaging and delivery
- Final Report

ROM Cost and Schedule:

<u>Task</u>	<u>Time Period</u>	<u>Cost</u>
Task 1:	12 months	\$275k
Task 2:	6 months	\$100k
Task 3:	3 months	\$100k
Task 4:	1 month	\$105k

Total Cost: \$580k

Deliverables:

- Interim report on Enhanced IR sensor brassboard laboratory testing
- Interim & final reports on the design & testing of the Enhanced IR sensor
- Prototype Enhanced IR Sensor, design drawings and software

Corporate Information:

Prime: XYZ Inc., 245 Chapman Street, Providence, RI 02905, Phone 401-xxx-xxxx, Fax 401-xxx-xxxx, ext 114, jjones@xyz.com

Team: ABC Company Research Laboratory, Anywhere, UT, John Jones, Phone, Email



Abstract Page 2

Description of Technology

- Complete and concise description of technology you are proposing
- No background, theory or extraneous material is necessary



Abstract Page 3

- T&E need
- Transition plan to support warfighting systems
- Brief assessment of the technical, performance and schedule risks



Guidance for 6.3 S&T

Appendix A to the BAA

- Miniaturization and hardening of prototype devices to facilitate technology demonstration
- Proof of technology feasibility and assessment of component operability and producibility
- Assessment of emerging COTs technologies potentially applicable to T&E
- Direct relevance to military test need
- Test/demonstration in laboratory, simulation and/or field environment
- Evaluation of architectures that facilitate the integration of EI system components



Bidder Challenges

- Ensure appropriate amount of S&T (6.3) content to your proposal
- Address a valid test & evaluation need
- Establish an effective transition opportunity
- High risk, high payoff technology
- Non-intrusive instrumentation
 - Minimal size
 - Extremely low weight
 - Low power
 - Affordable cost



BAA Points of Contact

■ Technical

- Dr. George Shoemaker, (401)832-5304,
shoemakergt@npt.nuwc.navy.mil
- Rob White, (401) 832-4897
whiterj@npt.nuwc.navy.mil

■ Contracts

- Nancy Howard, (401)832-1545,
howardns@npt.nuwc.navy.mil

■ Website

- <http://www.npt.nuwc.navy.mil/contract>